The Sidereal Messenger.

CONDUCTED BY WM. W. PAYNE,

Director of Carleton College Observatory.

MAY, 1887.

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Thou Lord in the beginning hast laid the foundation of the earth, and the heavens are the works of thy hands.

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The Messenger will be published monthly except for Aug. and September.

Subscription price per year (ten numbers) $2.00.

Communications should be addressed to the Editor, Northfield, Minnesota.

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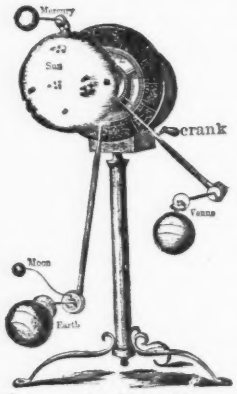

HELIOTELLUS.

When the Earth's axis is pointed to the north, it will continue so pointing throughout the revolution, and will be in the Ecliptic. The Earth rolls over from west to east, and if the Equator be continued to the sky, it will meet the Equinoctial. So with the Ecliptic, if continued, it will come near to the Moon, near to Mercury, near to Venus, and always to the Sun, for the ecliptic plane.

I have now in my possession all the Heliotelluses for sale, made with a set of tools costing $25,000, which tools were afterwards destroyed by fire. They were so accurately made that the Heliotellus cannot now be duplicated for less than $250 each. The greatest impediment I find in their introduction is the Tellurian, which makes a false showing of the heavenly movements. It is a device in which the Earth's axis wabbles around the zenith and never points to the north. This is the greatest bearier to the comprehension of this most sublime of the sciences. The Heliotellus shows so near the truth that it is not hard to comprehend.

In high schools, seminaries, colleges, and all places of learning we find many globes and maps of the earth, but where can one be found having the Equator of the Earth so constructed that if continued it will meet the Equinoctial in the right place on the sky? Every child should have a truthful understanding of science. The Ecliptic should be correctly understood. All instruments which show imperfect teaching are hurtful; those which teach correctly are useful. The one should be rejected, the other sought for, and when found should be prized even as a "pearl of great price." Three hundred such I now possess, all perfectly made, and I now propose to sell two hundred at the reduced price of $80 each, or for $65, the price of one, I will send four, each well packed in a strong box to carry by express anywhere. Address,

HENRY WHITALL,

BELVIDERE SEMINARY, BELVIDERE, N. J.

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The Sidereal Messenger,

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VOL. 6, NO. 5. MAY, 1887. WHOLE NO. 55.

THE ECCENTRICITIES AND INCLINATIONS OF THE ASTEROIDAL ORBITS.*

PROFESSOR DANIEL KIRKWOOD.

For the Messenger.

The average eccentricity of the 264 asteroids whose orbits have been calculated is 0.157. This is about equal to the mean eccentricity of Mercury, and exceeds the maximum of any other major planet. An inspection of the table of elements shows that while but one orbit is less eccentric than the earth's, sixty-eight depart more from the circular form than the orbit of Mercury. These large eccentricities seem to indicate that the forms of the asteroidal orbits were influenced by special causes. It may be worthy of remark that the eccentricity does not appear to vary with the distance from the sun; being nearly the same for the interior members of the zone as for the exterior.

The inclinations of the orbits are thus distributed:

From 0° to 4°	69
4 to 8	82
8 to 12	59
12 to 16	31
16 to 20	8
20 to 24	8
24 to 28	6
28 to 32	0
above 32	1

One hundred and fifty-two—considerably more than half—have inclinations between 3° and 11°, and the mean of the whole number is about 8°,—slightly greater than the inclina-

* Extracted from an unpublished work on the Minor Planets.

tion of Mercury, or that of the plane of the sun's equator. The smallest inclination, that of Massalia, is 0° 41′, and the largest, that of Pallas, is about 35°. Fifteen minor planets, or nearly six per cent of the whole number, have inclinations exceeding 20°. Does any relation obtain between high inclinations and great eccentricities? These elements in the cases named above are as follows:

Asteroid.	Inclination.	Eccentricity.
Pallas	34° 42′	0.238
Istria	26 30	0.353
Euphrosque	26 29	0.328
Gallia	25 21	0.185
Æthra	25 0	0.380
Eukrate	24 57	0.236
Eva	24 25	0.347
Niobe	23 19	0.173
Eunice	23 17	0.129
Electra	22 55	0.208
Idunna	22 31	0.164
Phocea	21 35	0.255
Artemis	21 31	0.175
Bertha	20 59	0.085
Henrietta	20 47	0.260

This comparison shows the most inclined orbits to be also very eccentric; Bertha and Eunice being the only exceptions in the foregoing list. On the other hand, however, we find over fifty asteroids with eccentricities exceeding 0.20 whose inclinations are not extraordinary. The dependence of the phenomena on a common cause can therefore hardly be admitted. At least the forces which produced the great eccentricity failed in a majority of cases to cause high inclinations.

THE PHENOMENA OF COOLING ENVELOPES.

FRANK H. BIGELOW.*

For the Messenger.

The argument for the sun-spots as vortex rings indicates that the sun is composed of a nucleus and a cooling envelope. An extension of the analysis to the characteristics of the solar system seems to fortify this conclusion by its explanation of several unsolved problems.

* Professor of Mathematics and Astronomy, Racine College, Racine, Wis.

It becomes evident, therefore, that the questions of solar gravitation ought to be transferred generally from the apparent radius of the envelope to that of the nucleus, when the data for the sun's contraction are selected. The envelope of the photosphere now forming is the type of similar ones that have been constructed during the development of the sun from its original nebulous material. When the densities and angular velocities of the nucleus and its successive envelopes are compared, it is clear that they are relatively greater for the former. Being intimately connected, the densities are in both cases increasing quantities, since the contracting core is giving off its lighter material to form the envelopes, which in turn must become heavier as they are formed later in time. The tangential velocity of the surface of the nucleus is a maximum which upon being transferred by radiation and ejection to the envelope induces in it a diminished velocity when reckoned in angular rotation. The central body of the sun is more viscous and dense, and rotates more rapidly than the observations of the envelopes would indicate.

The normal reaction of forces resulting from the discharge of envelope material pursue parabolic paths which, extended backward into the nucleus, do not pass through its center, but on the side from which rotation proceeds, causing the angular acceleration of the nucleus due to contraction to be retarded by a very significant amount in its integral of time. The discharge of the same material produces also a heat reaction proportional to the work expending in the lifting.

These considerations enable us to introduce important modifications into the usual statements of Laplace's Nebula Hypothesis. The principal feature therein contained is that equatorial rings are thrown off from the surface of the contracting sun whenever its angular velocity is sufficient to make the centrifugal overbalance the central forces, and that the planetary distances mark the stages of this process. The objection is clear that such an accelerating velocity is incompatible with the apparent circular disk of the sun, being a total violation of the laws of mechanics. Upon the theory of cool-

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ing envelopes no such acceleration is demanded, for it is certain that wide intervals, increasingly so at the earlier stages of condensation, have existed between the nucleus and envelope, and that thus the formation of planets was never a phenomenon of the surface of the contracting sun. Also it is seen that the mechanical work of lifting these immense envelopes through the convectional spaces is balanced only by a retardation of the central angular velocities.

An inspection of the orbital velocities of the planets, in miles per second, indicates approximately the acceleration of the successive envelopes, from which it is possible to compute the radius of the nucleus at each critical position. The problem is very complicated, however, since it includes the consideration that the first materials to be thrown off were generally of low densities and would cool at greater radial distances. These suggestions tend to relieve analysis of some objections that have hitherto hindered mathematical investigations in this direction.

The same theory becomes applicable to formation of the secondary systems. The envelope which changes into any particular planet, after having passed through the stages of solar shell and ring, and finally secondary sphere, still retains the capabilities of further contraction. Following the example of the central body it develops a succession of envelopes which become its attendant satellites. The uniformity in this process as applied to the sun and the planets should likewise be extended to the stars, and it therefore is a law of universal operation.

The explanation of the origin of vortex rings proceeded upon the lines that the elliptical nucleus was surrounded by a spherical shell in which was produced an acceleration of the equatorial regions by the residual forces of the continuous bombardment. As the condensation of these materials increases, the figure of the spherical shell changes to elliptical, since the gaseous constitution tends towards greater densities, while the polar regions will be spirally drawn towards the equator and finally be laid bare under the tangential stresses.

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At this stage the acceleration produced by the nucleus upon the ring will proceed rapidly, while local concentrations enable the ring to be drawn by the principal point of accumulation into a secondary sphere. This center of mass receives a motion of rotation either direct or retrograde, from the moment of indifferent equilibrium, according as the following portion of the ring advances over and the preceding part is retarded under its center of gravity, or conversely. In the case of Neptune, when the general motion of the ring was very slow, it seems to have coiled up in a retrograde spiral, but from some minimum of orbital velocity the formation has been uniformly direct. It should be considered that the motion of the central mass at first was very uncertain, and it is not inconceivable that there was an oscillation in it before its first rotation took place.

Some of the planetary problems now receive an obvious solution. The exterior group of planets are of great mass because the volume of their respective envelopes is in proportion to the law of the radii. Their density depends upon the material originally composing them and it must have been quite gaseous. They have each gone through the process of forming several successive envelopes, Neptune one, Uranus four, Saturn seven, Jupiter four. The surface belts of Jupiter and Saturn each indicate such typical envelope phenomena, as equatorial acceleration, unequal diameters, and the varying aspects due to adjustment of the effects of radiation, cooling and gravity. The great red spot on Jupiter and the spots of considerable duration often compared to the sun-spots are therefore signs of processes in the envelope now forming. Whether another satellite can be cast off depends upon the degree to which condensation has already gone. The rings of Saturn look like the theoretical section of an unbroken envelope when the density layers are exposed. The observation that the principal ring is thicker, as shown by the bend in the shadow at that place, is also quite probable if they were formed by the evolution of a proper envelope. The present appearance of equilibrium may or may not be an anomaly of the natural

process. The asteroids present another peculiar type of development wherein a series of envelopes and a number of local condensations indicate their probable origin. The inner group of planets are of greater density than the outer, since a long continued expenditure of material from the sun would leave only heavy matter for their constitution. The asteroids therefore seem to mark a decided increase in the density of the remaining matter left for envelope formations. The cooling of the planets proceeds more rapidly as solid particles preponderate in the mass considered. It should be observed that the friction of such solids in gaseous suspension generates the force of electrical repulsion which we perceive has reached an enormous development in the sun's photosphere.

The envelopes during their transformations will pass through many irregular forms and when they are regarded as screens upon the central luminary, it is apparent that the emission of light and heat to distant parts of the system will be controlled by their temporary condition. If the envelope is transparent a full transmission of solar energy takes place, but on being cooled absorption is greatly increased. Hence a long secular thermal variation occurs which will cause cosmical changes of a corresponding nature in the planets dependent upon the sun. They have gone through a series of fluctuations to be counted by the number of envelopes produced after themselves. The Earth has thus endured two cycles of diminished heat and light, while Venus and Mercury in turn surrounded the sun as envelopes. At the epoch of the Venus-shell the Earth itself was enveloped by the Moon and was thereby screened from the influence of solar changes, its own internal energies of heat being also vigorous. The rupture of the Venus and Moon envelopes occurring somewhat simultaneously would again expose the Earth, by that time much cooled, to the full radiant heat of the sun. The production of the Mercury envelope gradually reduced this heat to the amount remaining during the geological Glacial Period, but the disruption of it allowed the quick recovery of the maximum at the Earth, thus restoring the warmer climatic conditions existing after the ice re-

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treated to the poles. The cooling of the photosphere, which is not relatively far advanced, points to a similar period of glaciation to come, only more severe and fatal by reason of continuous development in the same direction of expenditure.

Finally the phenomena of the variability of the stars are seen to depend upon the same cause. The stars are necessarily going through these processes of envelope development, exhibiting a secular waning of light, so that Gould's surmise of a general variability of the stars is well founded. During the time of the disruption of envelopes the rotation about the central body of shells more or less broken will produce the quick maxima and minima changes of light observed to exist in individual stars. It may be possible, by close examination of the sequence of intermediate magnitudes, to reconstruct the approximate figure of the rotating interposed screen. This subject opens up a wide field for conjecture in the study of details, but they can be verified by laboratory models of light effects, showing the velocity of revolution and the portions of the shell or ring broken away by its local attractions.

Racine College, March 21, 1887.

A METHOD OF DERIVING THE RIGHT ASCENSION AND DECLINATION OF A HEAVENLY BODY FROM SEXTANT OBSERVATIONS, AND ITS APPLICATION TO THE DETERMINATION OF TERRESTRIAL LONGITUDE.

SEVERINUS J. CORRIGAN, WASHINGTON, D. C.

For the Messenger.

The determination of the apparent position of a heavenly body, with the greatest possible precision, can be effected only by means of the complicated and expensive instruments of a fixed observatory. But, for some practical purposes, the utmost attainable precision is not a prime requisite; approximate, yet entirely satisfactory, results can be easily obtained by any one expert in the manipulation of that simple but very efficient and comparatively inexpensive instrument the sextant.

This fact has led me to devise a method of computing, from sextant observations, the right ascension and the declination of any celestial body visible to the naked eye, or through the small telescopes which usually accompany the sextant.

This method, while it is sufficiently accurate, is extremely simple and can be readily comprehended by any one at all familiar with the most ordinary processes of spherical trigonometry and their application to astronomy, *i. e.*, to the solution of the triangles formed upon the celestial sphere by the coördinates and the angular distances apart, of any two heavenly bodies.

The principal observational data which are employed in the computation are the angular distances of the body, whose coördinates are to be determined, from any two prominent fixed stars whose right ascensions include that of the body. This condition that the right ascension of the body should lie between that of the stars is not an essential one, but is imposed simply as a matter of convenience in regard to the sign of a certain trigonometrical function as will hereafter be shown.

The observed distances are not the true ones, because they are affected by refraction which operates so as to render the observed distances always less than the true ones. Representing the difference in arc by q, or a correction to the observed distance, its value can be determined, in any case, through the solution of two triangles having a common angle Q, or the difference of the azimuths of the two bodies, and the sides z', Z'; z, Z; and d', d, the first two quantities being the observed zenith distances of the two bodies; the second two their zenith distances corrected for refraction, while d' and d represent respectively the observed and the true angular distances of the bodies from each other. As q is always small its value can be accurately determined by means of the following equation:

$$\sin q \sin d' = \cos Q (\cos h' \cos H' - \cos h \cos H) + (\sin h' \sin H' - \sin h \sin H) \qquad (1)$$

in which the quantities h and H are the altitudes correspond-

ing to z and Z, respectively. Since for each value of h' and of H' there is a corresponding value of h and of H, it is obvious that the second member of equation (1) can be easily tabulated in two parts, the arguments for both being h' and H'. Then, for any values of these arguments, we have only to take, from the first part of the table, the proper quantity, multiply it by cos Q, add to the result the quantity taken from the second part of the table, and multiply the whole by cosec d'. The resulting quantity will be the sine of the correction to be added to the observed distance in order to obtain the true one. The coefficient cos Q can be determined from the same triangles in the following manner: Let $\Sigma = \frac{1}{2}(z' + Z' + d')$ and $\sigma = \Sigma - d'$, then from the equation

$$\cos \tfrac{1}{2} Q = \sqrt{(\sin \Sigma \sin \sigma . \operatorname{cosec} z' \operatorname{cosec} Z')} \qquad (2)$$

Q can be obtained.

The second member of this equation can be tabulated in two parts, one for $\sqrt{(\sin \Sigma \sin \sigma)}$ and the other for $\sqrt{(\operatorname{cosec} z' \operatorname{cosec} Z')}$. The arguments for the first part will be $(z'+Z')$ and d'; for the second part z' and d'; or instead of the zenith distances z' and Z', it may be better to use the corresponding altitudes h' and H'.

Then all that is necessary in order to find the value of Q is to take, for any values of the arguments h', H' and d', the proper logarithm from each part of the table; the sum of these logarithms will be the log cos $\frac{1}{2} Q$. It is to be remarked that into the above formulæ only the *mean* refraction enters; the corrections for the height of the barometer and of the thermometer being neglected.

Since these corrections are, in most cases, very small and as they will be greatly reduced in the subsequent process of computation, the omission of them will not, generally, materially affect the final result; but should it be necessary to regard it, x or the second refraction correction to the observed distance can be obtained from the equation

$$x = (q \div r)\, c \qquad (3)$$

in which q has the value given by equation (1), r is the differ-

ence between the mean refraction of the two bodies, and c the difference between the combined barometrical and thermometrical corrections to these mean refractions. If desired, x can be tabulated for values of q, r and c, which quantities are to be expressed in seconds of arc, and r and c are to be obtained from the ordinary refraction tables. For the tables to be constructed by means of equations (1), (2) and (3), four place logarithms are more than sufficient, and in taking out quantities from these tables, for any arguments, only first differences need be used in the interpolation.

A third correction to the observed distance is necessary when the body observed is the moon or a planet, this correction being simply the apparent semi-diameter of the body, which is to be applied to the distance in the usual way, additive if the limb observed be the nearer and *vice versa*.

The computed data required are the right ascension and polar distance of any two selected stars. These coördinates, for all prominent stars, can be taken from the ephemeris for any given time. The process is then as follows: Select any two stars, one of them to the west and the other to the east of the body. Designate, in any case, the more westerly of the two as first star, and the other as second star. Let a represent the polar distance of the former, b that of the latter, and D the included angle at the pole, or the difference of right ascension between the stars. These polar distances and the angular distance between the stars form a triangle in which it is necessary to find this angular distance which we will call Δ, and the angle A included by a and Δ. This can be done by means of the equations:

$$\left.\begin{aligned} \tan c &= \cos D \tan a \\ c' &= b - c \text{ (either being greater)} \\ \cos \Delta &= \cos a \cos c' \sec c \end{aligned}\right\} \qquad (4)$$

By putting $S' = \frac{1}{2}(a + b + \Delta)$, and $s' = S' - b$, we have, from which to find A, the equation,

$$\cos \tfrac{1}{2} A = \sqrt{(\sin S' \sin s' \operatorname{cosec} a \operatorname{cosec} \Delta)} \qquad (5)$$

Then in the triangle formed by d_1 or the corrected distance of the body from the first star, d_2 or its corrected distance from the second star, and Δ, we have to find the angle B included by Δ and d_1. It is given by the equation,

$$\cos \tfrac{1}{2} B = \pm \sqrt{(\sin S'' \sin s'' \operatorname{cosec} \Delta \operatorname{cosec} d_1)} \qquad (6)$$

in which $S'' = \tfrac{1}{2}(\Delta + d_1 + d_2)$, and $s'' = S'' - d_2$.

It is to avoid the use of the lower sign in this equation, that the condition was imposed that the right ascensions of the stars should include that of the body. But in some cases it may be advisable to take both stars on one side. In this case the lower sign would have to be used and the angle would be the supplement of $\tfrac{1}{2} B$. We have now a triangle in which the known quantities are the sides a and d_1 and the included angle $P = (A \pm B)$, the lower sign to be used when the polar distance of the body is less than b. But the comparison stars can be so selected that only the upper sign need be used.

It will be seen that P is the angle of position of the body with reference to the first star, and that this method is analogous to the differential method employed in connection with the equatorial, in which the distance is measured by the filar micrometer and the position micrometer measures the angle P.

The third side of the triangle referred to above is unknown, and is one of the required coördinates of the body, viz., the apparent polar distance.

Calling it p, we have for finding its value the equations,

$$\left.\begin{aligned} \tan e &= \cos P \tan a \\ e' &= e - d_1 \text{ (either being greater)} \\ \cos p &= \cos a \cos e' \sec e \end{aligned}\right\} \qquad (7)$$

In the same triangle the angle D_1 at the pole, included by a and p, is the difference of right ascension between first star and the body. Its value can be obtained from the equation,

$$\sin D_1 = \sin P \sin d_1 \operatorname{cosec} p. \qquad (8)$$

Adding D_1 to the apparent right ascension of first star, we obtain the apparent right ascension of the body. Thus, by means of the above equations, the apparent right ascension

and declination of a celestial body can be determined. As a check, we can compute D_2, or the angle at the pole included by p and b, from the equation,

$$\cos \tfrac{1}{2} D_2 = \sqrt{(\sin S''' \sin s''' \operatorname{cosec} b \operatorname{cosec} p)} \qquad (9)$$

in which $S''' = \frac{1}{2}(b + d_2 + p)$, and $s''' = S''' - d_2$.

The value of D_2 derived therefrom is the difference of right ascension between the body and the second star, and if we *subtract* it from the latter it will give the right ascension of the body, and this will agree with that derived from the first star if the computation has been accurately made.

When p is great this check will not be very rigorous. The most accurate way will be to compute D_2 directly from b and d_2, as D_1 is computed from a and d_1.

It is obvious that in the method above proposed we have a means of determining terrestrial longitude; for, since it is applicable to all celestial bodies visible to the naked eye, it enables one to determine from sextant observations the apparent right ascension of the moon, whence, by means of the proper tabular reductions, the geocentric right ascension of that body can be deduced.

Then, by comparing this with the values given in the ephemeris for each hour, we can obtain the Greenwich mean time of the observation, using for this purpose the "difference of right ascension for one minute," which is given in connection with the hourly ephemeris. In view of the fact that the method of Lunar Distances for the determination of longitude at sea has fallen into comparative desuetude, and as the chronometer furnishes an easy and generally accurate means of obtaining a knowledge of the longitude, it may seem superfluous to propose this new method; but, since cases may occur in which other than a chronometrical determination is advisable or even necessary, and since the Lunar Distances still occupy a prominent place in the Nautical Almanac, the presentation of this method may be of interest, particularly as it possesses some points of superiority over the ordinary Lunar Distance method.

The first and probably the greatest is that while lunar distances must be computed for each and every year, the method here proposed suffices, with the assistance of simple and easily constructed tables, for an indefinite number of years before or after any epoch that may be chosen, and the only quantities that are to be taken from the ephemeris are already given therein for other purposes. Second, the required observations are fewer and more easily taken than those for the ordinary method, an interval of even an hour being admissible for the purpose of making them. Third, the process of computation tends to greatly reduce instrumental or observational errors, by reason of a smaller quantity being deduced from a larger, and on account of the fact that the observed distances will lie opposite sides of the moon. Fourth, it does not require any knowledge whatever of the Greenwich time, or of the longitude, and only an approximate knowledge of the latitude, and is thus, in one sense, an absolute method.

This method is as short and easy as that of the ordinary Lunar Distance. The process is about the same as that just given, differing mainly in this, that instead of the star places being the apparent ones for the time of the observation, they are the mean places for any chosen epoch.

Thus the right ascensions and the polar distances and the trigonometrical functions thereof, which are required in the subsequent computation, and also the quantities computed from equation (4), can be regarded as constants and tabulated for each set of stars that may be selected. We can have as many sets of stars and their corresponding tables of constants as may be necessary to determine the right ascension of the moon at any time during the period of its visibility.

The following is the form of the table referred to, arranged for a set of stars which I intend to use in an example illustrative of the method:

TABLE IV.

EPOCH 1885.0.

First Star (Fomalhant).		Second Star (Achernar).	
	h *m* *sec*		*h* *m* *sec*
R. A.	22 51 17.66	*R. A.*	1 33 25.53
a	59° 46′ 06.7″	*b*	32° 10′ 43.4″
Log *a*	0.234518	Log *b*	9.798799
Log *a′*	9.701995	Log *b′*	9.927571
Log *a″*	9.9365	Log *b″*	9.7264
A_1	33° 16′ 10″	A_2	117° 07′ 44″
Log m_1	8.3820	Log m_2	7.4472
Δ	39° 06′ 59″		
Log Δ	0.200041		
D	41°		
Log *n*	9.6757		

In the above table, *a* and *b* are the polar distances of first and second stars respectively. Logs *a*, *a′*, *a″*, are the logarithms, respectively, of the tangent, cosine and sine of *a*. Logs *b*, *b′*, and *b″*, are the same functions of *b*. Log *m* is the logarithm of the proper motion in right ascension of each star, expressed in seconds of time. Δ is the angular distance between the stars, and *A* is the angle included by *a* and Δ. Log Δ is the cosec of Δ. *D* is the difference of right ascension between the stars, and log *n* is the value of log sin *A* sin *a*. The two last quantities, *D* and log *n*, are to be used only in cases where there is but one observer.

When the observed distances have been corrected for refraction, by the application of quantities taken from tables constructed by means of equations (1), (2) and (3), and also for semi-diameter, the direct computation of D_1 or the difference of right ascension between the moon and the first star can be made by means of equations (5), (6), (7) and (8). Equation (7) will give the apparent polar distance or the declination of the moon, and equation (8) the value of D_1, hence the apparent right ascension of the moon referred to the mean equinox of the epoch but uncorrected for the star's aberration.

The moon's place must be reduced to the equinox of the time of observation, by means of precession and nutation tables constructed with the moon's right ascension and declination as arguments. The values taken from the precession table are to be multiplied by T or the time from the epoch expressed in years and fractional parts thereof. If the time of observation be after the epoch, T will be positive, but if before, it will be negative. The nutation is to be tabulated in two parts, one of which is to be multiplied by the sine of the mean longitude of the moon's ascending node, or Ω, and the other by the cosine of the same quantity. The second part of the nutation will be, generally, very small and in most cases can be neglected. The value of Ω can be taken from the ephemeris for any given date, or it can be derived from the equation,

$$\Omega = 92.6^\circ - T.\ 19.3^\circ$$

in which T is the time from 1890.0.

The right ascension of the first star must receive a correction for aberration, which can be tabulated with the day of the year as the argument, and intervals of half a month are small enough for an accurate interpolation using only first differences.

When these corrections have been applied, we will have the apparent right ascension of the moon for the time of observation. The parallax in right ascension must then be applied in order to obtain the geocentric right ascension for comparison with the hourly ephemeris of the moon.

The value of this parallax, in seconds of time, can be obtained from the equation,

$$\Delta a = \frac{(\rho \cos \varphi' \sec \delta) \sin \pi \sin t'}{15 \sin 1''} \qquad (11)$$

in which φ' is the geocentric latitude of the place, ρ the corresponding radius of the earth, π the moon's equatorial horizontal parallax, and t' its apparent hour angle. Since for each value of φ or the geographical latitude there is a corresponding value of φ' and of ρ, it is evident that the second member of equation (11) can be tabulated for values of φ and of δ, and

for given values of π. If we take π equal to 54′, 58′ and 62′, and form three tables, one for each value of π, and with the arguments φ and δ, the value of the parallax factor can be readily interpolated therefrom.

The value taken from the table is then to be multiplied by sin t' or the moon's apparent angle, which is computed from the equation,

$$\sin \tfrac{1}{2} t' = \sqrt{(\cos S \sin s \sec \varphi \operatorname{cosec} p)} \qquad (12)$$

in which $S = \frac{1}{2}(\varphi + p + H)$, and $s = S - H$. The value of t' need be only approximate and four place logarithms are sufficient for an accurate computation.

Finally a correction for the proper motion of the first star is necessary when that quantity is considerable, or when the time of observation is so far from the epoch as to produce a sensible correction.

As I propose to illustrate this method by a practical example, a reference to the Tables becomes necessary, but since it is impracticable, in this connection, to set forth these Tables at length, a recapitulation of them in their proper order must suffice. Reference will be made in the examples only to the number of the Table.

Table I (Parts 1 and 2).—For the determination of cos Q, the coefficient for first part of Table II. Arguments for first part are $(h' + H')$ and d'. For second part, h' and H'. (See equation 2.)

Table II (Parts 1 and 2).—For the determination of first refraction correction to the observed distance. Arguments for both parts are h' and H'. (See equation 1.)

Table III.—For finding the second refraction correction, due to the height of the barometer and the thermometer. (See equation 3.)

Table IV.—Constants for each set of comparison stars.

Table V.—Factor of parallax in R. A. to be multiplied by sine of t, or moon's apparent hour angle. Arguments, latitude and moon's declination. (See equation 11.)

Table VI.—For precession correction. Arguments, moon's R. A. and Dec.

Table VII.—For nutation correction, in two parts, both with arguments, moon's R. A. and Dec. First part to be multiplied by sin Ω, and second by cos Ω.

Table VIII.—Correction for aberration. Argument, day of the year.

An important point in favor of this method is its practicability, or the facility with which the observations can be made. The two distances d_1' and d_2' are the only quantities that need be determined with considerable accuracy, and even in them an error of 20″ will not materially affect the resulting longitude.

The moon's altitude will in most cases be sufficiently exact if its error be under 5′, while the altitudes of the two stars need be only roughly observed; it will suffice if the observed values are within a degree of the true ones. With two observers the measurements can be easily made, the distances being observed simultaneously, and the local mean time carefully noted; then the moon's altitude is taken and also the time. As the moon's hour angle which is to be computed from this altitude is for the time of the observation of the distance we must apply to the hour angle a correction due to the interval between the times of the two observations. This correction is simply the interval itself, converted into arc at the rate of 14.5′ to one minute of time.

The altitudes of the stars are then observed or they may be taken *before* the other measurements. If the stars are west of the meridian they should be observed first, and *vice versa*.

It will probably happen in the majority of cases that there is but one observer, yet, even in this event, accurate results can be easily obtained by a device of computation. Plenty of time can be taken by the observer for his observations, an interval of even an hour being admissible.

He begins by taking the distance d_1'; then the moon's altitude is observed and then the distance d_2'; the local mean time

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of each of these observations being carefully noted. The two star altitudes can be taken before or after, as may be most convenient.

On account of the interval between the observation of the distances the resulting longitude must receive a correction Δl, which is expressed by the equation,

$$\Delta l = \pm i\,(1 - k\,n) \qquad (13)$$

in which i is the interval between the observations of the distances expressed in seconds; $k = d_1 \div (d_1 + d_2)$; n represents sin A sin a, these quantities being constants and placed in Table IV, as already stated. The upper sign is to be used when d_2 is increasing during the interval, and *vice versa*.

In order to determine which sign is to be used we must have a criterion, and one is readily obtained in the following manner: Let $D_2 = D - D_1$, in which D is the difference of the right ascensions of the two stars and is placed as a constant in Table IV, and D_1 is the value already derived in the computation from equation (8).

$$\text{Then } \cos Y = \sin D_2 \operatorname{cosec} d_2 \sin b \qquad (14)$$

sin b being constant and taken from Table IV. Then in the equation $X = I + Y$ (c), I is the inclination of the apparent path of the moon and is determined by the equation $\tan I = \frac{Diff.\ of\ Dec.}{Diff.\ of\ R.\ A.}$ these differences being given in the hourly ephemeris for one minute. I will be positive if the moon be moving northward, otherwise negative. If in equation (c), X be greater than 90°, d_2 will be increasing and the upper sign in equation (13) is to be used, but when X is less than 90°, d_2 will be decreasing and the correction Δl will be negative. Since I lies between 0° and 29°, it will suffice to take 15° as its mean value, except in cases where X is very nearly 90°.

We are now prepared to present examples illustrative of this method. Two will be given, one representing a case where the observations are taken simultaneously and the date is only 3 *years* from the epoch, while the second example will treat of

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Computation of Corrections to Moon's R. A.

Parallax.	Precession.	Nutation (1st part).	Nutation (2nd part).	Aberration.	Proper Motion.
				Sec.	
Tab. V, log 2.2921	Tab. VI, log 0.5494	T. VII, log — 9.9507	T VII, log 8.3502	T. VIII, +1.7	T. IV, log ∞
Log sin t — 9.1252	log T — 0.4771	log sin Ω 9.6968	log cos Ω — 9.9383		log T ∞
— 1.4173	— 1.0265	— 9.6475	— 8.2885		∞
Nat number — 26.1 sec.	— 10.5 sec.	— 0.5 sec.	0.0 sec.	+ 1.7 sec.	

Sum of Correction, — 35.5 sec.

Computation of Moon's R. A.

Table IV, Δ 34° 15′ 22″ Log Δ 0.24962 Log cos P — 9 87819 Log sin P 9.81641
d_1 32 27 39 " cosec 0.27325 Table IV, log a 9 98658 " " d_1 9.72975
d_2 17 09 23 Log tan c — 9.86477 " cosec p 0.02401
83 52 24 " sin D_1 9.57017
S'' 41 56 12 " sin 9.82498 c^1 143° 46′ 45″
d_2 17 09 23 d_1 32 27 39 D_1 21° 49′ 10″
s'' 24 46 49 " sin 9.62232 c 111 19 06 (in time) 1h 27m 16.7s
2) 19 96717 Tab. IV, R. A. 5 08 33.8
Log cos ½ B 9.98358 Log cos c — 9.56056 6 35 50.5
" sec c — 0.09326 Sum of cor. — 35.5
B 31° 18′ 46″ Tab IV, log a' 9.85609 Moon's R.A. 6 35 15.0
Table IV A 107 44 56 Log cos p 9.50991
P 139 03 42
p 71° 07′ 25″

	h	m	^{m}sec		h	m	sec	
Ephemeris value of Moon's R. A.	6	35	15.0	at	16	00	00	G. M. T.
Computed " "	6	35	15.0	corr	0	00	00	
Diff.	0	00	00.0		16	00	00	G. M. T.
				Local M. T.	10	51	48	
				Longitude	5	08	12	West

The point was therefore in lat. 38° 53′ N. Long. 5h 08m 12s west of Greenwich, or in the city of Washington, D. C.

EXAMPLE I.

At a point in lat. 38° 53′ N. on January 8, 1887, at 10*h* 51*m* 48*s* P. M. local mean time, the apparent distance of the moon's nearer limb, from Capella, was 32° 10′ 41″, and from Pollux 16° 52′ 42″. App. alt. of moon's upper limb, east of meridian, 69° 12′. Alt. of Capella 77° 24′. Alt. of Pollux 68° 01′. Barometer 30.5 inches. Thermometer 15°. To determine the longitude.

PREPARATION OF THE DATA.

First Star (Capella).		Moon.			Second Star (Pollux).	
Obs. distance	32° 10′ 41″	Moon's apparent altitude		69° 12′	Obs. distance	16° 52′ 42″
Moon's corrected *S D*	16 24	" corrected *S D*		16	Moon's corrected *S D*	16 24
d_1'	32 27 05		H'	68 56	d_2'	17 09 06
h_1'	77° 24′		Ref.	00	h_2'	68° 01′
			H	68 56		
Log table I (Part 1)	8.8844	H 68.56			Log table I (Part 1)	9.5253
" " " (" 2)	0.5528	φ 38.53	Log sec	0.1088	" " I (" 2)	0.4356
Log cos ½ Q	9.4372	ρ 71.07	Log cosec	0.0240	Log cos ½ Q	9.9609
		178.56				
Q	148° 14′	S 89.28	" cos	7.9689	Q	47° 54′
Log cos Q	— 9.9295	H 68.56			Log cos Q	9.8259
Log table II (Part 1)	— 5 6441	s 20.32	" sin	9.5450	Log table II (Part 1)	— 5.8909
	+ 5 5736			2)17.6467		— 5.7168
Nat number	+ .000038		" " ½t'	8.8234	Nat number	— .000052
Table II (Part 2)	+ .000050		t'	— 7° 40′	Table II (Part 2)	+ .000076
	+ .000088					+ .000024
Log	5.9445		π =	0° 59′ 10″	Log	5.3802
Log cosec d_1'	0.2702		Ω =	150 10 00	Log cosec d_2'	0.5304
Log sin q	6.2147				Log sin q	5.9106
d_1'	= 32° 27′ 05″		Epoch	1890.0	d_2'	= 17° 09′ 06″
1st cor. for ref. = q =	34		Date of observation	1887.0	1st cor. for ref. = q =	17
2nd " " " =	00		T = —	3.0	2nd " " " =	00
d_1	= 32 27 39	Log coeff. for precession and proper motion = log T =		— 0.4771	d_2	= 17 09 23
		Log coeff. for par. in R. A. = log sin t' =		— 9.1252		
		Log coeff. for nutation = log sin Ω =		9.6968		
		Log coeff. for nutation = log cos Ω =		— 9.9383		

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Computation of Corrections to Moon's R. A.

Parallax.	Precession.	Nutation (1st part).	Nutation (2nd part).	Aberration.	Proper Motion.
				Sec.	
Tab. V, log 2.1385	Tab. VI, log 0.4903	T. VII, log — 0.0201	T VII, log — 8.6013	Table	T. IV, log 8.3820
Log sin t' — 9.9750	log T — 1.4675	log sin Ω 9.7773	log cos Ω 9.9034	VIII, 1.44	log T — 1.4675
— 2.1135	— 1.9578	— 9.7977	— 8.5047		— 9.8495
— 129.87 sec.	— 90.74 sec.	— 0.63 sec.	0.00 sec.	+ 1.44 sec.	— 0.71 sec.

Computation of Moon's R. A.

Table IV,

Δ 39° 06′ 59″ Log Δ 0.20004 Log cos P — 9.84057 Log sin P 9.85804

d_1 46 21 44 " cosec 0.14043 Tab. IV, log a 0.23452 " " d_1 9.85957

d_2 63 09 13 Log tan c — 0.07509 " cosec p 0.00160

148 37 56 " sin D_1 9.71921

74 18 58 " sin 9.98352 c 130° 04′ 16″ D_1 31° 35′ 29″

63 09 13 46 21 44 h m sec

11 09 45 " sin 9.28689 c' 83 42 32 D_1 (in time) 2 06 21.93

2) 19.61088 Tab. IV, R. A. 22 51 17.65

Log cos ½ B 9.80544 Log cos c' + 9.03973 Moon's mean " 0 57 39.58

" sec c — 0.19129 Cor (except par) 1 30.64

B 100° 34′ 42″ Tab IV, log a' + 9.70199 Moon's ap. R. A. 0 56 08.94

Table IV, A 33 16 10 Log cos p — 8.93301 Par cor 2 09.87

P 133 50 52 Moon's geo R. A. 0 53 59.07

p 94° 55′ 00″

	h	m	sec		h	m	sec	
Ephemeris value of Moon's R. A.	0	52	58.89	at	17	00	00	G. M. T.
Computed " " "	0	53	59.07					
Diff.		1	00.18					
Log diff.			1.7795					
Log diff. for 1 minute			0.3366					
Log corr to G. M. T.			1.4429	corr		27	44	
Greenwich M. T.					17	27	44	
Local mean time					9	40	00	
l					7	47	44	
Δl				+		14	22	
Longitude					8	02	06	West.

Correction due to Interval between Observations.

Table IV, D 41°

D_1 32

D_2 9

Log sin D_2 9.1943

Log cosec d_2 0.0495

" table IV 9.7264

" cos Y 8.9702

Y 85°

I 15

X 100

$X > 90°$, correction positive.

Log $\frac{d_1}{d_1+d_2}$ = log k = 9.6266

Table IV, log n = 9.6757

Log kn = 9.3023

kn = .2006

Log $(1 - kn)$ = 9.9028

Log i = 3.0326

Log Δl = 2.9354

Δl 861.8

$14^m\ 21.8^s$

EXAMPLE II.

At sea in lat. 55° 20′ S. on Aug. 29, 1855, at $9^h\ 40^m$ P. M. local mean time, the apparent distance of the farther limb of the moon, from Fomalhaut, was 46° 30′ 26″. At 9:45 P. M. the app. altitude of the moon's lower limb was 7° 07′. At $9^h\ 57^m\ 58^s$ P. M. the apparent distance of the moon's farther limb from Achernar was 63° 19′ 16″. The app. altitude of Fomalhaut was 52° 35′, and of Achernar 48° 29′. Barometer 31 inches. Thermometer 20°. Height of eye 18 ft. above sea level. To determine the longitude.

PREPARATION OF THE DATA.

First Star (Fomalhaut).		Moon.		Second Star (Achernar).	
			h m sec		
Obs. distance	46° 30′ 26″	Time of obs. of 1st distance	9 40 00	Obs. distance	63° 19′ 16″
Moon's corrected *S D*	16 11	Red. to sidereal time	1 35	Moon's corrected *S D*	16 11
d_1'	46 14 15		9 41 35	d_2'	63 03 05
		Sid. time at mean noon	10 31 38		
h_1'	52° 35′	Sid. time of observation	20 13 13	h_2'	48° 29′
Log table I (Part 1)	9.8887	Moon's app. R. A.	0 56 09	Log table I (Part 1)	9.8545
" " " (" 2)	0.1097		19 17 04	" " I (" 2)	0.0908
Log cos ½ Q	9.9984	t' =	— 4 42 56	Log cos ½ Q	9.9453
		(in arc) =	— 70° 44′		
Q	9° 50′	COEFFICIENTS FOR TABULAR CORRECTIONS.		Q	56° 19′
Log cos Q	9 9936			Log cos Q	9.7440
Log table II (Part 1)	— 6.5158	π =	1° 00′ 10″	Log table II (Part 1)	— 6.5499
	— 6 5094	Ω =	36 11 00		— 6.2939
Nat number	—.00032	Epoch	1885.00	Nat number	— .00020
Table II (Part 2)	+.00175	Time of observation	1855.66	Table II (Part 2)	+ .00166
	+.00143	T	— 29.34		+ .00146
Log	7.1553	Log coeff. for precession and		Log	7.1644
Log cosec d_1'	0.1414	proper motion = log T =	— 1.4675	Log cosec d_2'	0.0508
Log sin q	7.2967	Log coeff. for par.		Log sin q	7.2152
		in R. A. = log sin t' =	— 9.9750		
d_1' =	46° 14′ 15″	Log coeff. for nu-		d_2' =	63° 03′ 05″
1st cor. for ref. = q =	6 48	tation = log sin Ω =	9.7776	1st cor. for ref. = q =	5 38
2nd " " " =	41	Log coeff. for nu-		2nd " " " =	30
d_1 =	46 21 44	tation = log cos Ω =	9.9034	d_2 =	63 09 13

COMPUTATION OF CORRECTIONS TO MOON'S R. A.

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a case in which the observations are taken at different times, the date of observation is nearly *30 years* from the epoch, and the refraction corrections are large. Thus the method is illustrated in all of its phases. The second example is based upon one given in Bowditch's Navigator, revised edition, page 139, for the Lunar Distance method. In this case there was an observation of d_1 only, and d_2' is a computed quantity deduced for the time of observation and the longitude, and therefore represents a correct observation.

In both cases the longitude comes out exact.

It will be seen that some of the work could be abridged. In some cases the refraction could be neglected. The second nutation correction in both examples given above could be disregarded and in most cases no attention need be paid to proper motion. *All* the corrections have been given so as to illustrate the *modus operandi* in any possible case.

On account of the interval between the observations of the distances, in the first example, the value of the moon's apparent polar distance will differ from the value for the time of observation of the altitude, and therefore will not give the proper value of t', or the hour angle. In general the difference will be too small to be regarded; but in some cases it may produce an appreciable effect. This can be avoided by computing the hour angle from the equation $t' = \theta - a'$, in which θ is the sidereal time of the first observation of distance and a' is the moon's apparent right ascension. The computation is carried on as before; the value of D_1 and the moon's right ascension (uncorrected) are obtained; then all the corrections to the latter, *except* that for parallax are applied. We will then have the value of a'. The sidereal time is derived in the usual manner, and then the value of t' by the above equation. Using this we obtain the moon's geocentric right ascension by the same process as in the first example. This method of obtaining t' is perhaps easier and better, even when the observations are simultaneous, than that of computing it from the moon's altitude, polar distance and the latitude. The computer can use either.

If we use this second method of determining the hour angle, the moon's altitude need be only very roughly observed, since, like the altitudes of the two stars, it will be used only for the refraction tables. The estimated center of the moon can be brought down to the horizon so that no correction for semi-diameter will be necessary. The other corrections may also be neglected.

This method is therefore shorter and easier than any in use, and the advantages claimed for it will be apparent to any one who will give it a close examination.

In the second example the only variable quantities that enter into the computation of D_1, being the distances d_1 and d_2, it is evident that the value of D_1, and therefore of the moon's apparent right ascension, can be tabulated for any values of d_1 and d_2, for each set of stars. Thus the right ascension can be taken directly from the table, doing away with the direct computation, and greatly reducing the labor.

This tabulation will also serve for the purpose of identifying the comparison stars; for the observer has only to take the approximate right ascension of the moon from the ephemeris and this will indicate the approximate values of d_1 and d_2 in the table. Then if he sets the index of the sextant at any one of these values, brings the reflected image of the moon into the field and revolves the instrument, the line of sight will pass near to the star. As the stars will generally be of not less than the second magnitude and in approximately known direction from the moon, no trouble will be found in picking up the right one even when the observer is not well acquainted with the geography of the heavens.

WORK OF THEODOR VON OPPOLZER.

Professor Theodor von Oppolzer, the only son of the celebrated physician Dr. Johann von Oppolzer, was born at Prague, October 26, 1841. His early years were spent at Leipsic, whence, while yet in his childhood, he moved to Vienna, as his father had been appointed professor at the university of that city. Here he studied physics, but his abilities and great pre-

dilection for mathematics induced him to devote all his spare time to the study of natural philosophy. In these studies he was aided by Dr. E. Weiss, the present Director of the Vienna Observatory, who soon recognized his eminent talents for Astronomy, and encouraged him to devote his life to that science. Oppolzer, who was possessed of independent means, sufficient to remove all necessity for seeking immediate employment, therefore constructed a well-appointed observatory after he had taken the degree of a Doctor of Physics. At this observatory he observed asteroids and comets during the years 1862 to 1872 with great zeal, and his computations of the orbits of such bodies were the first papers by which he introduced himself to the astronomical world. For such work he was especially qualified by the quickness and certainty with which he conducted extended numerical computations. He published numerous papers on this subject.

He also published all his valuable theoretical researches in this branch of Astronomy in an excellent "Lehrbuch zur Bahnbestimmung der Kometen und Planeten," of which the first volume appeared 1870; and in a second, totally revised and much enlarged edition, 1882. The second volume was published in 1880. In this classic work the author has in fact reconstructed on a more comprehensive plan the *Theoria Motus* of Gauss. The theories upon which the calculation of the orbits of comets and planets depend are discussed so fully and exhaustively, that the work forms, indeed, a Treatise on Astronomy, "not only useful to the practical Astronomer, but of the highest value to the Mathematician who desires to know the exact manner in which the dynamical formulæ he is acquainted with are actually applied in practice to the calculation of orbits." This most important work has been recently translated into French by Prof. Ernest Pasquier, of Louvain.

In the year 1873 Prof. Oppolzer was entrusted by the Austrian government with the astronomical work for the *Europaische Gradmessung*. In this position, which he held till his death, being in his last years chairman of the Austrian Commission of the *Europaische Gradmessung*, he showed an extraordinary

ability as an organizer, and executed a long series of telegraphic longitude operations between various cities of Austria amongst each other, and with the capitals of other countries. For many weeks in the summer of 1876 operations were undertaken at the Royal Observatory, Greenwich, by Professor Oppolzer's assistants for the purpose of making the time observations and telegraphic observations necessary for determining the longitudes of Vienna and Berlin, connected also in some measure with Munich and Paris. All the observations for this very extensive work are finished, but unfortunately the reductions are not very far advanced. In connection with these investigations he also conducted a series of pendulum experiments for determining the intensity of gravity at Vienna, and he made a very interesting and important study of the vibrations of the stand of the pendulum and their influence on the time of its oscillation. But here also his very premature death prevented him from discussing more than a small part of these extremely delicate researches, for which he devised special methods of observation and reduction.

In the year 1881 Oppolzer published "Syzygien-Tafeln für den Mond," which were intended to supply a simple and convenient means of finding very approximately the time of New and Full Moon, particularly in the case of an ecliptic syzygy, and of calculating all the circumstances of an eclipse without the necessity of having recourse to the Solar and Lunar Tables.

But the most important work undertaken by Oppolzer is his "Canon der Finsternisse" [Table of eclipses], which will be found to be an invaluable basis for all historical researches connected with solar eclipses, and will form an enduring monument of the power of its author.

This masterly paper contains not only the elements of eclipses of the Sun, but also of those of the Moon from 1207 B. C. to 2162 A. D. The elements are given for all the eclipses partial and central occurring during this period of time.

The tables furnish the computations of 8,000 Solar Eclipses,

of which about 2,220 are total, 355 annular and total, 2,605 annular, and 2,820 partial.

Of the Moon, 5,200 eclipses are computed; for which the tables give not only the date, but also the magnitude, the time of the middle of the eclipse, and the geographical position of the point on the earth where the Moon at that moment is at the zenith.

Appended to the work are 160 charts, in which is laid down the central line of all Solar Eclipses visible in the northern hemisphere, and as far as 30° south latitude. Partial eclipses of the Sun, and those which are central only in regions more south than 30° are not mapped.

The work forms vol. lii. of the *Memoirs of the Imperial Academy of Sciences* at Vienna.

This noble undertaking Oppolzer was only just able to bring to a conclusion, for it was but a few hours before his death that he read the last proof-sheets of it.

Besides all this, Oppolzer was engaged during the last years of his life in researches on planetary disturbances, especially on the theory of the motion of the Moon, on astronomical refractions, and on the resisting medium, &c.

From this brief record of his more important researches it will readily be understood that his life was one of constant work, and that he was enabled to perform all he did only by an indefatigable diligence, a very remarkable power of memory, quickness of perception, and intuitive grasp of whatever he studied.

Von Oppolzer was appointed in 1876 Professor of Astronomy at the University of Vienna, and received besides this, various other distinctions from the Austrian Government and several foreign sovereigns. He was also Member of the Imperial Academy of Sciences at Vienna, Honorary Member of the Royal Academy at Munich, Correspondent of the Institute of France, and Fellow of many other scientific bodies. He was elected an Associate of the Royal Astronomical Society on Jan. 9, 1874.

In the middle of November 1886 Oppolzer returned to

Vienna somewhat ill, after attending the Paris International Conference on Weights and Measures, and the meeting of the Permanent Commission of the *Europaische Gradmessung* at Berlin. No one would have considered, however, from his appearance, that his end was so near. At first his illness was thought to be a kind of malaria, but it very soon proved a serious disease of the heart, of which he suddenly died, on the morning of December 26, at the early age of 45 years.—*E. W. in "Monthly Notices."*

EDITORIAL NOTES.

Space will be given hereafter in the MESSENGER, regularly for the publication of the titles, prices and the names of publishers of standard and useful books on Astronomy. Good books for sale, or books wanted will be included. The charge for such notices will be 5 cents per nonpareil line for each issue. Subscribers are offered one line monthly free.

The Holden-Proctor Unpleasantness.—It is reported that President Holden of the California State University and Director of the Lick Observatory, published an article in the San Francisco *Examiner*, March 1, in which he said something that greatly displeased Professor R. A. Proctor who was in Florida at the time. Seeing the article Mr. Proctor replied through the same paper (March 27) condemning Professor Holden's treatment of him in very severe language, and implying that the animus of the attack was due to the detection of a gross literary offense therein named, and besides, woefully berating some of Professor Holden's astronomical work while in connection with the U. S. N. Observatory at Washington. We have not seen the articles referred to in the *Atlantic Monthly*, nor that of March 1 in the San Francisco *Examiner*, and do not personally know of the merits of these accusations. If true and fairly presented, Mr. Proctor is right, in just severity and dignified silence both of which he has chosen to use.

Professor Hough's Catalogue of 209 New Double Stars.—It was an agreeable surprise to find the *Astronomische Nach-*

richten Nos. 2778–79 wholly given to the publication of Professor Hough's catalogue of two hundred and nine new double stars. Observers giving attention to this kind of work well know how thoroughly the northern heavens have been explored and that the easy doubles remaining uncatalogued are comparatively few.

The following synopsis in reference to distance of components is interesting :

Distance.	Stars.
0.″ to 0.5″	25
0.5 " 1.0	25
1.0 " 2.0	43
2.0 " 5.0	77
over 5.0	39
Total	209

The Astronomical Theory of the Ice Age.—I am glad to see the attention of astronomers again called to this subject. I am, however, unable to acquiesce in the criticisms of Professor McFarland and ask your permission to make a short reply.

First. I did not imagine that I could dispose of the elaborate theory of Dr. Croll in two pages of your journal. I thought Sir Robert Ball had been induced to give his adhesion to that theory on insufficient grounds and as Sir Robert's name is likely to carry a good deal of weight with astronomical readers I wrote to point out the defect of his argument.

Second. I think Professor McFarland mistakes the correspondence between the summer heat and the winter cold at the period of greatest eccentricity. The earth receives on the whole the same (or rather a slightly greater) amount of heat from the sun in the course of the year. Consequently if the summer is shorter than the winter its heat is *more* above the average than the winter cold is below it; and the excess of summer heat above winter cold is greater the more the summer is shortened and the winter lengthened. The shorter summer brings with it no diminution of the total heat.

Thirdly. Though we have no means of producing a suffi-

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ciently intense heat on the earth to render the melting of snow or ice absolutely instantaneous, time as such does not enter into the problem of melting at all. What is required to change a certain quantity of ice or snow at a given temperature into water at a given temperature is a certain quantity of heat, and (if we could exclude interference from other sources of heat or cold) it is perfectly indifferent whether this quantity of heat is applied to it in an hour or in twenty years. As to the effects of intense heat in removing a snow-cap, I believe snow-caps on volcanoes have sometimes been melted in a single night. Time as such is not a factor in the melting.

One fact cited by Prof. McFarland tells, I think, against himself. If intense cold can in a day or two form an ice-cap which long exposure to the oblique rays of the sun fails to melt, it would seem that the great agent in forming snow or ice-caps is not duration but intensity. Is it not natural to conclude that in melting them also intensity, not duration, is the great element to be looked to? W. H. S. MONCK.

Dublin, Ireland, March 17, 1887.

Daylight Occultation of a Tauri, observed at the Chabot Observatory, Oakland, Cala., March 29th, 1887, F. M. Campbell, Director.—The *Disappearance* was observed with a power of 90 on the 8-inch Clark equatorial; nearly at middle of moon's limb at $3^h\ 28^m\ 59.6^s$ by sid. chronometer; star bright and steady.

For the *Reappearance* a power of 200 diameters was used; the star flashed out sharply, near the expected spot, and apparently exactly on the bright edge at $4^h\ 56^m\ 49\ 8^s$ by chron. The time carefully determined on the evening of the 30th (29th cloudy), and kept by standard sidereal and mean time clocks, the rates of which agreed exactly in giving the chronometer used a correction for true local sidereal time of $+3^m\ 16.3^s$ for Dis., and $+3^m\ 16.4^s$ for Reap. We have, therefore:

Dis., "*a Tauri*": $3^h\ 32^m\ 15.9^s$, local sid. time.
Reap., "*a Tauri*": $5^h\ 00^m\ 06.2^s$.

Position of Observatory: Lat. $= +37°\ 48'\ 05''$; Long. $= 8^h$

09*m* 06.3*s* W. All the observations and reductions have been made by myself. CHAS. B. HILL, ASSISTANT.

Occultation of Aldebaran.—This occultation occurred during daylight. At immersion the sky was clear, but the atmosphere was very unsteady. The instrument was the 6.4 inches equatorial, objective, by Clark & Sons. The star was quite red, and was visible in the finder of $1\frac{15}{16}$ inches.

The moon was five days old and the star disappeared instantaneously about 88° from the north point; but the ash grey limb of the moon was not visible.

At the reappearance from behind the bright limb the atmosphere was much disturbed, and a slight haze was gathering over the sky. The border of the moon was blurred and very unsteady, and the star did not reappear with the brightness expected, but its almost sparkling red color left no doubt whatever of the time to the nearest tenth of a second. The outermost limit of the moon's apparent disc was fuzzy and decreasing in brightness outward. The time which elapsed from the reappearance until the star left this factitious limb was two and a half or three seconds, when it appeared much brighter. The star emerged about 240° from the north point. The error of the chronometer was determined by transit observations during the evening; the rate is one-tenth of a second per diem and very regular.

RECAPITULATION.

Name of Star.	Mag.	Obsr.	Power.	Local Sidereal Time of Obsn.			Remarks.
				h	*m*	*s*	
a Tauri..	1	G. D.	90	3	31	18.8	Immersion; Instantaneous; good; star red.
a Tauri..	1	G. D.	250	4	59	09.2	Emersion; " " " "

Geographical position of the observatory: Latitude 37° 47′ 24.75″ north; Longitude 122° 25′ 40.54″ west.

Observer G. D. = George Davidson.

Davidson Observatory, San Francisco, March 29, 1887.

Astronomical Observations at Dresde (French).—The first

part of the published observations of the observatory of B. d'Engelhardt at Dresde for the year 1886 are promptly before us, and find welcome place in the astronomical library.

The description of instruments, instrumental constants, geographical position of the observatory, observations of the moon, double stars, culmination of the moon, occultations, phenomena of the satellites of Jupiter, temporary stars in the nebula of Andromeda and X^1 Orionis, besides much of the ordinary work common to observatories like that of Dresde, is found in this large quarto volume of 220 pages. Four full page plates of the fine buildings, instruments and observing facilities are a neat and fitting supplement to the volume.

Intra-Mercurial Observations July 29, 1878.—After reading Professor Young's statement published in the March MESSENGER, that "the two objects seen by Swift were certainly not the two seen by Watson," etc., we were not fully satisfied with our own knowledge concerning the intra-Mercurial observations made at Denver, Colo., July 29, 1878, and accordingly asked Professor E. Colbert of Chicago, who was the chief of the observing party referred to, if we might examine the original papers in his possession concerning the observations made at Denver under his direction. He kindly assented, and we have before us as we write,—

1. The lithograph star-map of the neighborhood of the sun, at the time of the eclipse, prepared by Mr. Colbert for the use of his party,—the particular copy which he tacked to his own observing post.

2. Professor Watson's private letter to Mr. Colbert, Dec. 24, 1878, giving a pencil drawing of the position of the sun, and his two planetary objects as related to Theta and Zeta Cancri after reduction.

3. Professor Watson's private letter to Mr. Colbert, May 27, 1879, concerning Dr. Henry Draper's statements and Professor Swift's observations.

4. Professor Watson's brief private letter to Mr. Colbert, Feb. 23, 1880, about negative evidence of the existence of

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intra-Mercurial planets given by a Washington astronomer and others.

5. A copy of Professor Colbert's letter to Dr. C. H. F. Peters concerning the observations.

6. Other papers, most of which have already appeared in print:

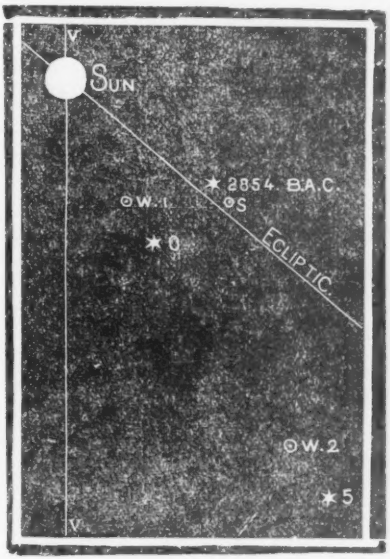
(1) Intra-Mercurial Planets by J. C. Watson, *American Journal of Science and Arts*, Oct. 1878.

(2) Report of the Solar Eclipse by the Chicago Astronomical Society.

(3) The Problematical Vulcan by Professor Watson as published in the Wisconsin *State Journal* under date of Feb. 18, 1880.

(4) Other papers with Prof. Colbert's statements.

From the maps above mentioned, and the correspondence explaining them the following cut has been made:



Little explanation is needed. *VV* represents a line perpendicular to the horizon at Denver at the time of the eclipse. W. 1, is Watson's planetary object first discovered, about 3° west of the sun and east of Theta Cancri. W. 2, is Watson's second planetary object, about 7° west of the sun and near Zeta Cancri (5) on the east side. The difference of declination of the sun and Theta at that time was less than ten minutes of arc; that of the sun and Zeta more than half a degree. Professor Watson had less confidence in the position of the second object, although carefully read from the circles of his instrument as was also the position of the first object.

On Professor Colbert's observing star-map is found a pencil mark west of star B. A. C. 2854, which, it is said, Professor Swift placed there soon after the observation and after hesitating a while in deciding whether it should be on the one side or the other of the star. That point is *s* in the cut. It is not a wonder that Professor Swift should be uncertain of part of the details of this important observation, in view of his sudden surprise and annoyance in finding his telescope hampered by the pole attached preventing motion to the eastward. Professor Colbert further says that Professor Swift's later adoption of Theta as probably one of the stars he observed was after he had called his attention to the fact that he could not possibly have seen 2854 (6½ mag.) during the eclipse.

Now, it is noteworthy that Professor Swift's object is very nearly in line with the sun and star, and so is Watson's first object. If Professor Swift was not certain on which side of the star to place his object, and had no means of measuring distance, and on the way home, as he says in his report, changed the first supposed distance between his objects from 12′ to 7′ (not from 7′ to 12′ as stated by Professor Young,—see Report of Chicago Astr. Soc.), is it not strongly probable that the two objects which he saw were Theta Cancri and Watson's first planet, especially since Professor Swift thinks Theta Cancri was one of the objects he saw in his single sweep to the west, and since Professor Watson swept carefully over the same ground twice and is sure that no other planetary object as

bright could have been near Theta? It should also be added that at the outset Professor Swift had set his instrument to follow a star in its diurnal motion, and hence it moved approximately in a parallel to the plane of the equator. Now, in reality, the stars Theta and Zeta Cancri, the sun and Watson's objects were all nearly on the same parallel of declination, and by sweeping to the west but twice the field of his glsss Professor Swift would certainly have picked up Zeta and Watson's object number two. His distance of 7′ between his two objects is the only troublesome element in making the two observers wholly agree. These statements, if entirely true, seem to us in no wise to weaken or lessen the value of Professor Swift's observation of *what* he saw, or its *direction;* but on the contrary his observation is a strong kind of testimony in support of the claim that Watson and himself independently discovered *something* near Theta Cancri which they both took for an intra-Mercurial planet. Hence it is simply just to say that all the evidence in the world of what other astronomers have not seen should not weigh much against such observations. What two experienced observers have seen independently can not be impeached by what a hundred others have not seen, not observing in the same field at the same time. Professor Watson's letters also throw light on some other points of interest, especially regarding statements of Dr. C. H. F. Peters and Dr. Henry Draper pertaining to Professor Watson's mode of observation.

Charlier's General Disturbance of Thetis by Jupiter (German).—The MESSENGER is favored with No. 2, Bandet 22, a paper published by the Royal Swedish Academy recently, being prepared by C. V. L. Charlier and entitled An Inquiry Concerning the General Disturbance of the Planet *Thetis* by Jupiter. The object of the writer is to furnish a more general method for the computation of disturbances than astronomers now have in view of the rapidly growing number of minor planets between Jupiter and Mars, thereby avoiding in some degree the special yearly work that must now be done for par-

ticular orbits. Hansen's well known treatise, entitled, "Explanation of a Suitable Method for Computing the Absolute Disturbances of the Small Planets," is the work probably most commonly used. This author speaks of the excellence of Hansen's methods as consisting of the compact form of development with large terms only in a single coördinate, though first presented by Cauchy was improved by Hansen for numerical computation in the complete system of checks furnished for the computer.

In the development of the function of perturbations generally this writer has given a few methods which he believes are to be preferred in many cases to those of Hansen. One slight modification is that his method makes it possible to take the coefficients of the development from tables, thereby lessening the labor of computation somewhat. Another peculiarity is the use of Gauss' transformation of elliptical integrals in computing the terms of the same order in relation to eccentricity simultaneously. A further advantage is claimed in tabulating results, which work is scarcely less than that of the development of the main function. The two arguments involved make the work intricate, which the writer seeks to simplify by noticing that one is constant during a half revolution of the planet, but that during the remainder of the path it changes by finite amounts. In this way the terms are made so small that tabulation is unnecessary.

This paper is published in quarto form, in large clear type, and contains 98 pages of well ordered matter.

General List of Observatories (French).—The most useful small publication that has recently come to hand for those who read the French is the "General List of Observatories, Astronomical Societies and Astronomical Publications" of the world which has been prepared by A. Lancaster, librarian of the Royal Observatory of Brussells. We take pleasure in calling the attention of our readers to it.

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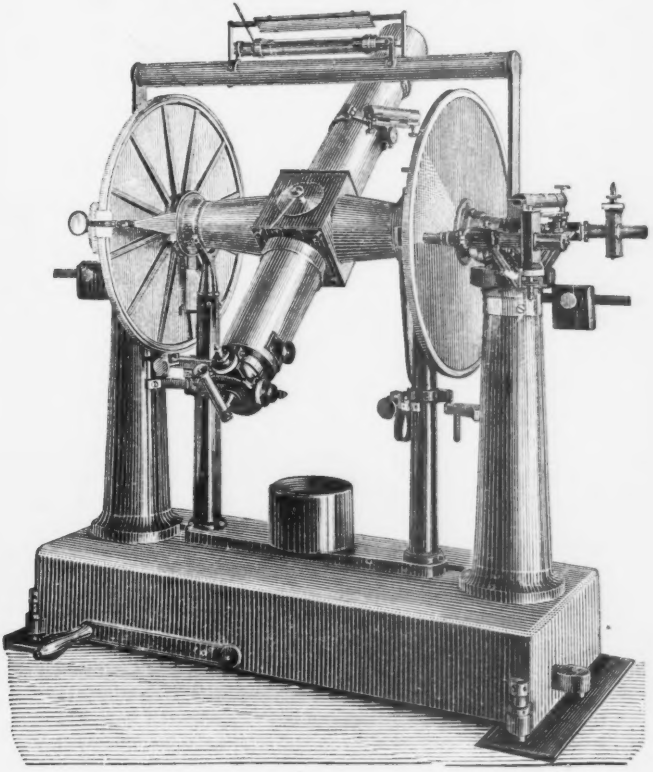

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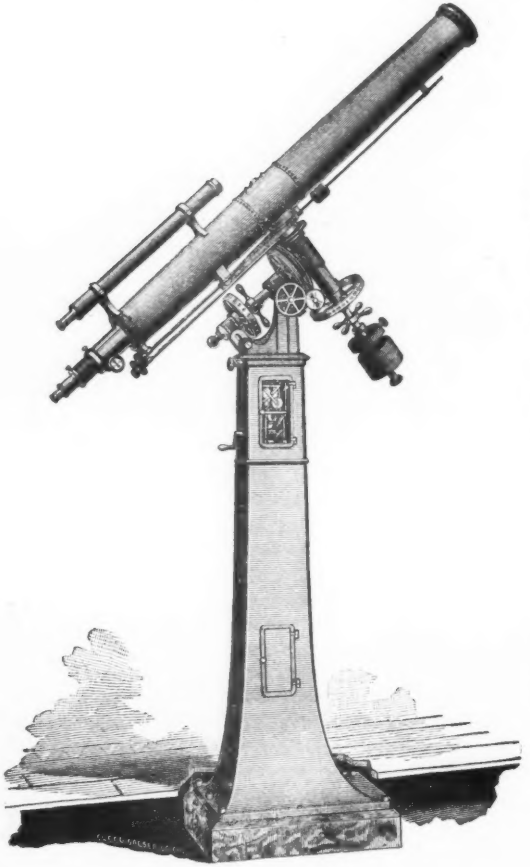

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